

What is claimed is:

1. A method of determining a defect-free or defect semiconductor integrated circuit, comprising:

5 a first measurement step for measuring a quiescent power supply current (QPSC) of a first semiconductor integrated circuit (IC), a plurality of times in a predetermined interval after stop of the operation of the first IC;

10 a first data calculation step for calculating a first feature data indicating a feature(s) of the measured QPSCs of the first IC;

15 a second measurement step for measuring a QPSC of a second semiconductor IC, a plurality of times in the same condition to that of the first IC after stop of the operation of the second IC;

a second data calculation step for calculating a second feature data indicating a feature(s) of the measured QPSCs of the second IC; and

20 a comparison and determination step for comparing a resemble between the first feature data and the second feature data, and determining the first and second ICs as defect-free ICs when the resemble is high or the first and second ICs as defect ICs when the resemble is low.

25 2. A method according to claim 1, wherein the

first and second ICs are formed on the same semiconductor wafer.

3. A method according to claim 2, wherein the IC comprises a complementary metal oxide semiconductor (CMOS) IC.

4. A method according to claim 1, wherein one of the first and second ICs is decided as a reference IC, the second measurement step and the second calculation step are carried out for other semiconductor IC as the second IC,

in the comparison and determination step, the second IC is determined as a defect-free IC when the resemble is high, or as a defect IC when the resemble is low.

5. A method according to claim 1, wherein in the first data calculation step, a first average QPSC of the measured QPSCs of the first IC and a first plurality of QPSC deviations of the measured QPSCs of the first IC which are (the measured QPSCs of the first IC - the first average) are calculated, in the second data calculation step, a second average QPSC of the measured QPSCs of the second IC and a second plurality of QPSC deviations of the measured QPSCs of the second IC which are (the measured QPSCs of the

the method further comprising a third data calculation step for performing a first regression analysis on the first plurality of QPSC deviations and

5 the second plurality of QPSC deviations to produce a
first regression line and calculating a gradient of the
first regression line, performing a second regression
analysis on the measured QPSCs of the first IC to produce
a second regression line and calculating a predicted
10 QPSC, and calculating a decision coefficient defined by
the following formula, and

$$1 - \frac{\sum (\text{measured QPSCs of the second IC} - \text{predicted QPSC})^2}{\sum (\text{second deviation})^2}$$

wherein, in the comparison and determination
15 step, the first and second ICs are resemble when the
decision coefficient is greater than a limit value, and
the deviation of the gradient and the ratio is in a
predetermined range.

6. A method according to claim 1, wherein

20 in the first data calculation step, a first average QPSC of the measured QPSCs of the first IC, a first standard deviation of the measured QPSCs of the first IC, and first normalized values defined as (the measures QPSCs of the first IC - the first average)/the

first standard deviation are calculated, and

in the second data calculation step, a second average of the measured QPSCs of the second IC, a second standard deviation of the measured QPSCs of the first IC, and second normalized values defined as (the measures QPSCs of the second IC - the second average)/the second standard deviation are calculated,

the method further comprising a third data calculation step for performing a first regression analysis on the first plurality of normalized values and the second plurality of normalized values to produce a first regression line and calculating a gradient of the first regression line, performing a second regression analysis on the first normalized values to produce a second regression line and calculating a predicted normalized value, calculating an average normalized value of the second plurality of normalized values, and calculating a decision coefficient defined by the following formula, and

$$1 - \frac{\sum (\text{second standard values} - \text{predicted standard value})^2}{\sum (\text{second standard values} - \text{average standard value})^2}$$

wherein, in the comparison and determination step, the first and second ICs are resemble when the decision coefficient is greater than a limit value, and

the gradient is in a predetermined range.

7. A method according to claim 1, wherein

in the first data calculation step, a first
average QPSC of the measured QPSCs of the first IC, a
first standard deviation of the measured QPSCs of the
5 first IC, and a first feature value defined by (the first
average QPSC / the first standard deviation) are
calculated,

in the second data calculation step, a second
10 average QPSC of the measured QPSCs of the second IC, a
second standard deviation of the measured QPSCs of the
second IC, and a second feature value defined by (the
second average QPSC / the second standard deviation) are
calculated, and

15 in the comparison and determination step, the
first and second ICs are resemble when the first and
second feature values are in a predetermined range.

8. A method according to claim 1, wherein

in the first data calculation step, a first
20 average QPSC of the measured QPSCs of the first IC, first
QPSC deviations which are (the measured QPSCs of the
first IC - the first average QPSC), and first feature
values defined by (the first QPSC deviations / the first
QPSC average) are calculated,

25 in the second data calculation step, a second

average QPSC of the measured QPSCs of the second IC,
second QPSC deviations which are the measured QPSCs of
the second IC - the second average QPSC, and second
feature values defined by (the second QPSC deviations /
5 the second QPSC) are calculated,

in the comparison and determination step, the
first and second ICs are resemble when the first and
second feature data are in a predetermined range.

9. A method of determining a defect-free or defect
10 semiconductor integrated circuit, comprising:

a first measurement step for measuring each
quiescent power supply current (QPSC) of each of a
plurality of reference semiconductor integrated circuits
(ICs), a plurality of times in a predetermined interval
15 after stop of the operation of the first IC;

a first data calculation step for calculating
each first QPSC average of measured QPSCs of each
reference IC, each first standard deviation of the
measured QPSCs of each reference IC, each of first
20 normalized values defined by ((the measured QPSCs - the
corresponding first QPSC average) / the corresponding
first standard deviation), each of first average
normalized value of each of first normalized values, each
of first feature value defined by ((each of the measured
25 QPSCs - the corresponding each first QPSC average) - (the

corresponding each first normalized values / the
corresponding each first standard deviation)), and the
maximum feature value among the first feature values;

5 a second measurement step for measuring a QPSC
of a test IC a plurality of times in the same conditions
to the reference ICs after stop of the operation of the
test IC;

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10 a second data calculation step for calculating
a second QPSC average of measured QPSCs of the test IC, a
second standard deviation of the measured QPSCs of the
test IC, second normalized values defined by ((the
measured QPSCs of the test IC - the second QPSC average)
/ the second standard deviation), a second average
normalized value of the second normalized values, and
15 second feature values defined by ((the measured QPSCs of
the test IC - the second average QPSC) - (the second
normalized values / the second standard deviation));

a comparison and determination step for
comparing the second feature value and the maximum
20 feature value and determining the test IC as a defect-
free IC when the second feature values is smaller than
the maximum feature value or a defect IC when one of the
second feature values exceeds the maximum feature value.

10. A method of determining a defect-free or defect
25 semiconductor integrated circuit, comprising:

5 a first measurement step for measuring a
quiescent power supply current (QPSC) of a reference
semiconductor integrated circuit (IC), a plurality of
times in a predetermined interval after stop of the
operation of the reference IC;

a first data calculation step for calculating a
first standard deviation of measured QPSCs of the
reference IC;

10 a second measurement step for measuring a QPSC
of a test IC a plurality of times in the same condition
of that of the reference IC after stop of the operation
of the test IC;

15 a second data calculation step for calculating
a QPSC average and a second standard deviation of
measured QPSCs of the test IC, and

a comparison and determination step for
comparing a parameter which is ((QPSC average - (the
second standard deviation / the first standard
deviation)) and a limit and determining the test IC as a
20 defect-free IC when the parameter is smaller than the
limit or the test IC as a defect IC when the parameter is
equal or greater than the limit.

11. A method of determining a defect-free or defect
semiconductor integrated circuit, comprising:

25 a first measurement step for measuring each

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quiescent power supply current (QPSC) of each of a plurality of reference semiconductor integrated circuits (ICs), a plurality of times in a predetermined interval after stop of the operation of the first IC;

5 a first data calculation step for calculating each first QPSC average of measured QPSCs of each reference IC, each first standard deviation of the measured QPSCs of each reference IC, and each of first coefficients defined by ((the measured QPSCs - the
10 corresponding first QPSC average) / the corresponding first standard deviation);

 a second measurement step for measuring a QPSC of a test IC a plurality of times in the same conditions to the reference ICs after stop of the operation of the
15 test IC;

 a second data calculation step for calculating a first QPSC average of measured QPSCs of the test IC, and second deviations defined by (the measured QPSCs of the test IC - the first QPSC average);

20 a third data calculation step for performing regression analysis on the first coefficients and the second deviations to produce a regression analysis, calculating a predicted coefficient from the regression line and a gradient of the regression line, and
25 calculating a decision coefficient by the following

formula, and

$$1 - \frac{\sum (\text{the first coefficients} - \text{the predicted coefficient})^2}{\sum (\text{the second deviations})^2}$$

a comparison and determination step for

5 comparing the test IC as a defect-free IC when the decision coefficient is greater than a limit and (the gradient / the second deviations) are in a predetermined range.

12. A method of determining a defect-free or defect
10 semiconductor integrated circuit, comprising:

a first measurement step for measuring each quiescent power supply current (QPSC) of each of a plurality of reference semiconductor integrated circuits (ICs), a plurality of times in a predetermined interval
15 after stop of the operation of the first IC;

a first data calculation step for calculating each first QPSC average of measured QPSCs of each reference IC, each first standard deviation of the measured QPSCs of each reference IC, each of first
20 normalized values defined by ((the measured QPSCs - the corresponding first QPSC average) / the corresponding first standard deviation), each of first average normalized value of each of first normalized values, and each of first feature value defined by ((each of the

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measured QPSCs - the corresponding each first QPSC
average) - (the corresponding each first normalized
values / the corresponding each first standard
deviation));

5 a second measurement step for measuring a QPSC
of a test IC a plurality of times in the same conditions
to the reference ICs after stop of the operation of the
test IC;

10 a second data calculation step for calculating
a second QPSC average of measured QPSCs of the test IC, a
second standard deviation of the measured QPSCs of the
test IC, second normalized values defined by ((the
measured QPSCs of the test IC - the second QPSC average)
/ the second standard deviation)), and second normalized
15 value deviation defined as (the second normalized values
- the average normalized values);

a third data calculation step for performing
regression analysis on the first coefficients and the
second deviations to produce a regression analysis,
20 calculating a predicted feature value from the regression
line and a gradient of the regression line, and
calculating a decision coefficient by the following
formula, and

$$1 - \frac{\sum (the\ first\ feature\ values - the\ predicted\ feature\ value)^2}{\sum (the\ second\ standard\ values - an\ average\ of\ the\ second\ standard\ value)^2}$$

a comparison and determination step for determining the test IC as a defect-free IC when the decision coefficient is greater than a limit and the gradient is in a predetermined range.

- 5 13. An apparatus for determining a defect-free or defect semiconductor integrated circuit, comprising:

 a first measurement means for measuring a quiescent power supply current (QPSC) of a first semiconductor integrated circuit (IC), a plurality of
10 times in a predetermined interval after stop of the operation of the first IC;

 a first data calculation means for calculating a first feature data indicating a feature(s) of the measured QPSCs of the first IC;

- 15 a second measurement means for measuring a QPSC of a second semiconductor IC, a plurality of times in the same condition to that of the first IC after stop of the operation of the second IC;

 a second data calculation means for calculating
20 a second feature data indicating a feature(s) of the measured QPSCs of the second IC; and

 a comparison and determination means for comparing a resemble between the first feature data and the second feature data, and determining the first and
25 second ICs as defect-free ICs when the resemble is high

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or the first and second ICs as defect ICs when the resemble is low.

14. An apparatus according to claim 13, wherein the first and second ICs are formed on the same semiconductor wafer.

15. An apparatus according to claim 14, wherein the IC comprises a complementary metal oxide semiconductor (CMOS) IC.

16. An apparatus according to claim 13, wherein one of the first and second ICs is decided as a reference IC,

the second measurement means and the second calculation means operate for other semiconductor IC as the second IC,

the comparison and determination means determines the second IC as a defect-free IC when the resemble is high, or as a defect IC when the resemble is low.

17. An apparatus according to claim 13, wherein the first data calculation means calculates a first average QPSC of the measured QPSCs of the first IC and a first plurality of QPSC deviations of the measured QPSCs of the first IC which are defined (the measured QPSCs of the first IC - the first average), and

the second data calculation means calculates a

second average QPSC of the measured QPSCs of the second IC and second plurality of QPSC deviations of the measured QPSCs of the second IC which are defined as (the measured QPSCs of the second IC - the second average),

5 the apparatus further comprising a third data calculation means for performing a first regression analysis on the first plurality of QPSC deviations and the second plurality of QPSC deviations to produce a first regression line and calculating a gradient of the first regression line, performing a second regression analysis on the measured QPSCs of the first IC to produce a second regression line and calculating a predicted QPSC, and calculating a decision coefficient defined by the following formula, and

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$$1 - \frac{\sum (\text{measured QPSCs of the second IC} - \text{predicted QPSC})^2}{\sum (\text{second deviation})^2}$$

wherein, the comparison and determination means comprises the first and second ICs and decides the both resemble when the decision coefficient is greater than a limit value, and the deviation of the gradient and the ratio is in a predetermined range.

18. An apparatus according to claim 13, wherein the first data calculation means calculates a first average QPSC of the measured QPSCs of the first IC,

a first standard deviation of the measured QPSCs of the first IC, and first normalized values defined as (the measures QPSCs of the first IC - the first average)/the first standard deviation, and

5 the second data calculation means calculates a second average of the measured QPSCs of the second IC, a second standard deviation of the measured QPSCs of the first IC, and second normalized values defined as (the measures QPSCs of the second IC - the second average)/the
10 second standard deviation,

 the apparatus further comprising a third data calculation means for performing a first regression analysis on the first plurality of normalized values and the second plurality of normalized values to produce a
15 first regression line and calculating a gradient of the first regression line, performing a second regression analysis on the first normalized values to produce a second regression line and calculating a predicted normalized value, calculating an average normalized value
20 of the second plurality of normalized values, and calculating a decision coefficient defined by the following formula, and

$$1 - \frac{\sum (\text{second standard values} - \text{predicted standard value})^2}{\sum (\text{second standard values} - \text{average standard value})^2}$$

wherein, the comparison and determination means compares the first and second ICs and decides the both resemble when the decision coefficient is greater than a limit value, and the gradient is in a predetermined
5 range.

19. An apparatus according to claim 13, wherein
the first data calculation means calculates a first average QPSC of the measured QPSCs of the first IC, a first standard deviation of the measured QPSCs of the
10 first IC, and a first feature value defined by (the first average QPSC / the first standard deviation),

the second data calculation means calculates a second average QPSC of the measured QPSCs of the second IC, a second standard deviation of the measured QPSCs of
15 the second IC, and a second feature value defined by (the second average QPSC / the second standard deviation), and

the comparison and determination means compares the first and second ICs and decides the both resemble when the first and second feature values are in a
20 predetermined range.

20. An apparatus according to claim 13, wherein
the first data calculation means calculates a first average QPSC of the measured QPSCs of the first IC, first QPSC deviations which are (the measured QPSCs of
25 the first IC - the first average QPSC), and first feature

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values defined by (the first QPSC deviations / the first QPSC average),

the second data calculation means calculates a second average QPSC of the measured QPSCs of the second IC, second QPSC deviations which are the measured QPSCs of the second IC - the second average QPSC, and second feature values defined by (the second QPSC deviations / the second QPSC), and

the comparison and determination means compares the first and second ICs and decides the both resemble when the first and second feature data are in a predetermined range.

21. An apparatus for determining a defect-free or defect semiconductor integrated circuit, comprising:

a first measurement means for measuring each quiescent power supply current (QPSC) of each of a plurality of reference semiconductor integrated circuits (ICs), a plurality of times in a predetermined interval after stop of the operation of the first IC;

a first data calculation means for calculating each first QPSC average of measured QPSCs of each reference IC, each first standard deviation of the measured QPSCs of each reference IC, each of first normalized values defined by ((the measured QPSCs - the corresponding first QPSC average) / the corresponding

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the maximum feature value or a defect IC when one of the second feature values exceeds the maximum feature value.

22. An apparatus for determining a defect-free or defect semiconductor integrated circuit, comprising:

- 5 a first measurement means for measuring a quiescent power supply current (QPSC) of a reference semiconductor integrated circuit (IC), a plurality of times in a predetermined interval after stop of the operation of the reference IC;
- 10 a first data calculation means for calculating a first standard deviation of measured QPSCs of the reference IC;
- a second measurement means for measuring a QPSC of a test IC a plurality of times in the same condition
- 15 of that of the reference IC after stop of the operation of the test IC;
- a second data calculation means for calculating a QPSC average and a second standard deviation of measured QPSCs of the test IC, and
- 20 a comparison and determination means for comparing a parameter which is ((QPSC average - (the second standard deviation / the first standard deviation)) and a limit and determining the test IC as a defect-free IC when the parameter is smaller than the
- 25 limit or the test IC as a defect IC when the parameter is

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equal or greater than the limit.

23. An apparatus for determining a defect-free or defect semiconductor integrated circuit, comprising:

5 a first measurement means for measuring each quiescent power supply current (QPSC) of each of a plurality of reference semiconductor integrated circuits (ICs), a plurality of times in a predetermined interval after stop of the operation of the first IC;

10 a first data calculation means for calculating each first QPSC average of measured QPSCs of each reference IC, each first standard deviation of the measured QPSCs of each reference IC, and each of first coefficients defined by ((the measured QPSCs - the corresponding first QPSC average) / the corresponding
15 first standard deviation);

a second measurement means for measuring a QPSC of a test IC a plurality of times in the same conditions to the reference ICs after stop of the operation of the test IC;

20 a second data calculation means for calculating a first QPSC average of measured QPSCs of the test IC, and second deviations defined by (the measured QPSCs of the test IC - the first QPSC average);

25 a third data calculation means for performing regression analysis on the first coefficients and the

second deviations to produce a regression analysis,
calculating a predicted coefficient from the regression
line and a gradient of the regression line, and
calculating a decision coefficient by the following

5 formula, and

$$1 - \frac{\sum (\text{the first coefficients} - \text{the predicted coefficient})^2}{\sum (\text{the second deviations})^2}$$

a comparison and determination means for
comparing the test IC as a defect-free IC when the
10 decision coefficient is greater than a limit and (the
gradient / the second deviations) are in a predetermined
range.

24. An apparatus for determining a defect-free or
defect semiconductor integrated circuit, comprising:

15 a first measurement means for measuring each
quiescent power supply current (QPSC) of each of a
plurality of reference semiconductor integrated circuits
(ICs), a plurality of times in a predetermined interval
after stop of the operation of the first IC;

20 a first data calculation means for calculating
each first QPSC average of measured QPSCs of each
reference IC, each first standard deviation of the
measured QPSCs of each reference IC, each of first
normalized values defined by ((the measured QPSCs - the

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corresponding first QPSC average) / the corresponding
first standard deviation), each of first average
normalized value of each of first normalized values, and
each of first feature value defined by ((each of the
5 measured QPSCs - the corresponding each first QPSC
average) - (the corresponding each first normalized
values / the corresponding each first standard
deviation));

10 a second measurement means for measuring a QPSC
of a test IC a plurality of times in the same conditions
to the reference ICs after stop of the operation of the
test IC;

15 a second data calculation means for calculating
a second QPSC average of measured QPSCs of the test IC, a
second standard deviation of the measured QPSCs of the
test IC, second normalized values defined by ((the
measured QPSCs of the test IC - the second QPSC average)
/ the second standard deviation)), and second normalized
value deviation defined as (the second normalized values
20 - the average normalized values);

a third data calculation means for performing
regression analysis on the first coefficients and the
second deviations to produce a regression analysis,
calculating a predicted feature value from the regression
25 line and a gradient of the regression line, and

calculating a decision coefficient by the following formula, and

$$1 - \frac{\sum (\text{the first feature values} - \text{the predicted feature value})^2}{\sum (\text{the second standard values} - \text{an average of the second standard value})^2}$$

- 5 a comparison and determination means for determining the test IC as a defect-free IC when the decision coefficient is greater than a limit and the gradient is in a predetermined range.

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